

GENERATION OF USEFUL SEMANTIC FEEDBACK FOR STUDENTS AND TEACHERS

M. Sánchez-Vera, F. Frutos-Morales, M. D. Castellanos-Nieves
M. P. Prendes-Espinosa, J. T. Fernández-Breis
Universidad de Murcia, Campus de Espinardo CP30100, Spain

C. Cruz-Corona
Universidad de Granada, CP 18015, Spain

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Abstract: Feedback is an important component of assessment in learning environments, because it allows students to know their learning flaws, and feedback information is also useful for teachers to design learning contents adapted to the needs of the students. Therefore, the availability of feedback constitutes a new learning opportunity. In this paper we describe an approach based on Semantic Web technologies for generating useful semantic feedback for both teachers and students.

1 INTRODUCTION

Student's knowledge or skills evaluation is a basic activity in both conventional education and e-learning. To date, different knowledge representation techniques have been used in computer-assisted open question assessment, such as semantic networks or lexical conceptual structures (see for instance (Whittingdon and Hunt, 1999)). These ones have made use of complementary techniques, including statistical techniques, natural-language processing, information extraction techniques, clustering, and Hybrid approaches. In the last years, Topic Maps (Maicher and Park, 2005) have been widely used for conceptualizing domains in educative settings. They can represent information using topics, relationships, and occurrences. They are thus similar to semantic networks and to both concept and mind maps in many aspects. However, their knowledge is not formalized and requires the definition of the topic map ontology. Non semantic approaches can also be found in literature. For instance, fuzzy sets have also been used for evaluating performance in eLearning settings (see for instance (Wang and Chen, 2008)).

On the other hand, the Semantic Web (Berners-Lee et al., 2001) proposes the idea that web contents

are defined and linked not only for visualization but for being used by applications. Moreover, Semantic Web technologies have been used in eLearning for the last years from different perspectives (see, for instance, (Devedzic, 2006; Fensel et al., 2003; Stojanovic et al., 2001)). In this way, our research group developed the OeLE platform to support teachers in the assessment of open questions-based exams by applying such technologies (Castellanos et al., 2008). This assessment approach demonstrated its usefulness in real courses for supporting exam marking. However, it did not allow students and teacher to know the main flaws of the students from the course knowledge perspective.

Feedback is indeed an important part of assessment processes since they allow both teachers and students to take actions to overcome the learning flaws demonstrated in the assessment tests. Furthermore, its availability is a new learning opportunity, so enhancing the learning-teaching process. Hence, in this work we address the generation of semantic feedback for both agents of the learning-teaching process. The OeLE platform will be then extended for providing such feedback. As a result, students will not only receive the mark for the exam, but also their learning flaws. On the other hand, teachers will know the strengths and

weaknesses of their students by doing the semantic analysis of the results of the exams.

2 ASSESSMENT IN OeLE

OeLE is an approach based on Semantic Web technologies for supporting teachers the assessment of exams. The whole picture of assessment in OeLE can be seen in Figure 1, and includes the following basic assessment entities:

- Course ontology: It models the knowledge of the course, and it must be written in OWL.
- Annotated exam: An exam is comprised of a set of open and closed questions. Each open question has a set of semantic annotations associated by the teacher, which constitutes the expected answer to that question.
- Annotated student's response to the exam: Semantic annotations are extracted from the response to each open question. This is a semiautomatic process that follows the algorithm presented in (Valencia et al., 2004).

Each semantic annotation consists in associating one or more elements of the course ontology to the question or to part of the student answer. Once the annotations have been obtained, OeLE gets automatically the marks for each question using the functions presented in (Castellanos et al., 2008).

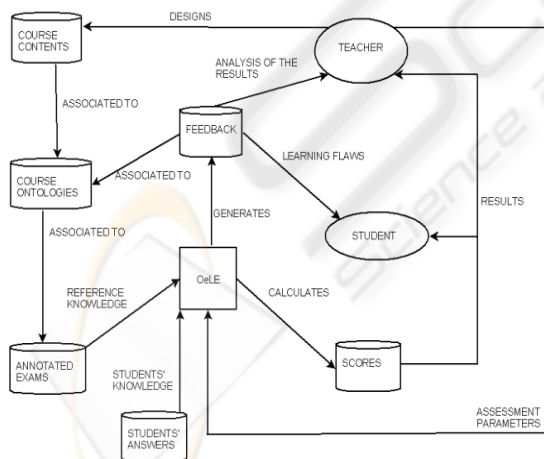


Figure 1: Assessment in OeLE.

As shown in Figure 1, feedback is then approached as the information received by both teachers and students after an exam is marked. Feedback is then obtained analysing the performance of the students in that exam. The generation of feedback is strongly

related to the marking approach, and it is obtained by analyzing the same sets of annotations. As a result of this process, both students and teachers will receive information about the knowledge the students do not have learnt, and will be able to perform actions to overcome such learning flaws.

3 FEEDBACK IN OeLE

In this section we will present how feedback is represented in OeLE, how it is generated and, finally, we will describe the particular feedback information generated for teachers and students.

3.1 Representing Feedback

The relevant concepts managed by OeLE to represent feedback are presented in this subsection.

Definition 1. Open Question

open_question: <desc, expected_answer, {open_question_annot_i}, value>
 where *desc* is the name of the question; *expected_answer* contains the correct answer to the question in natural language; *open_question_annot_i* are the semantic annotations defined for such open question; and finally, *value* is the number of units given to the student in case of success.

When an open question is created by a teacher, its expected response must be annotated with respect to the course ontology. For this purpose, each open question has a set of (concepts, relations, attributes and values) annotations associated.

Definition 2. Open Question Annotation

open_question_annot:<entity_annot, quantitative_value>
 where *entity_annot* represents the annotation for the knowledge entity in the course ontology; and *quantitative_value* is the numerical score associated to the question. It stands for the importance of the knowledge entity in the context of the individual question.

There are three types of *entity_annot*, for concepts, relations and attributes, which associates the particular knowledge item of the course ontology to the question.

Definition 3. Open Question Answer

open_question_answer= <text_answer, {answer_annotation_i}>
 where *text_answer* is the answer of the student in natural language; and *answer_annotation_i* are the

semantic annotations obtained from the textual answer, which are defined next.

Definition 4. Answer Annotation

Answer_annotation= \langle entity_annot, ling_exp \rangle
 where *entity_annot* is defined as for Question_Annotation; and *ling_exp* represents the text of the answer associated to the knowledge entity.

The generation of feedback requires the definition of new elements, which are defined next.

Definition 5. Feedback Annotation

Feedback_annotation= X, where X in {correct, wrong}

A feedback annotation has the value *wrong* in case the answer annotation is not similar enough to any annotation of the same open question, what is determined by the value of the similarity threshold used. Otherwise, the value is *correct*.

Once we know which answer annotations are correct and which are wrong, positive and negative feedback structures are respectively defined.

Definition 6. Positive Feedback for an Answer

positive_feedback(op)=
 $\{$ answer_annotation_i, feedback_annotation_i $\}$ such that feedback_annotation_i=correct.

Definition 7. Negative Feedback for an Answer

negative_feedback (op)=
 $\{$ answer_annotation_i, feedback_annotation_i $\}$ such that feedback_annotation_i=wrong.

Then, the combination of both definitions would provide the definition of the feedback provided to a student for a particular answer to an open question.

Definition 8. Student Feedback for an Answer

student_feedback(op)=
 \langle text_answer, positive_feedback(op), negative_feedback(op) \rangle

Finally, we can define the feedback generated for a teacher for a particular open question:

Definition 9. Teacher Feedback for an Open Question

teacher_feedback(op)= \cup student_feedback_i (op)

3.2 Obtaining Feedback

The algorithm for feedback generation works on a question-by-question basis and feedback items are generated in parallel to the calculation of the marking score. Next, we describe how feedback

annotations are generated for a particular answer of an open question.

For each semantic annotation of the student's answer, the following process is executed. First, the semantic similarity between one semantic annotation of the student's answer and all the annotations of the expected one of the same ontological category is obtained. The result of this process is a table whose rows are the annotations of the student's answer, and whose columns are the annotations of the expected one. Each cell has then the value of the semantic similarity.

For each annotation of the expected answer, the most similar annotation of the student is selected. If such similarity is higher than the threshold, it is marked as correct and included in the positive feedback group. Otherwise, it is marked as wrong and included in the negative group. It should be noticed that the algorithm checks that we can only select one item of the student's answer for one item of the expected one.

3.3 Customised Feedback

Feedback has been incorporated in the OeLE platform for both teachers and students. The OeLE platform offers a desktop application for teachers and a web-based access for students, so the corresponding software artifacts had to be modified appropriately. This section has then two streams, one per type of agent involved in the teaching-learning process: teacher and student.

3.3.1 Providing Feedback to Teachers

The OeLE platform allows for making several corrections to the same exam by changing the assessment parameters. Teachers can receive the feedback of any of such marking processes, since each exam has a marking configuration associated. Hence, once the teacher selects the desired exam, the analysis dialog, shown in Figure 2, is displayed.

The upper part of the dialog contains general information about the exam, showing some statistics such as mean, standard deviation, highest and lowest scores, and the description of the marking criterion used ("Calificación estricta"). This description is provided by the teacher when the criterion is created. The lower part of the dialog provides the semantic interpretation of the exams, using the course ontology to perform such analysis. This analysis calculates how many students have answered correctly each ontological entity associated to the questions, and how many have done it wrong. To

this end, such entities are classified into two sets: a) entities acquired by the students (“aspectos mejor adquiridos”); and b) entities not acquired by the students (“aspectos peor adquiridos”). Both sets are shown in the lower part of the dialog. Hence, the teacher has access to which concepts, relations and attributes have been acquired better or worse by the students, although in the figure only concepts are shown. In the example shown in the figure, the concept interactivity (“interactividad”) has been correctly answered by all the students, whereas simple design (“diseño simple”) has only been wrongly answered by 53% of the students.

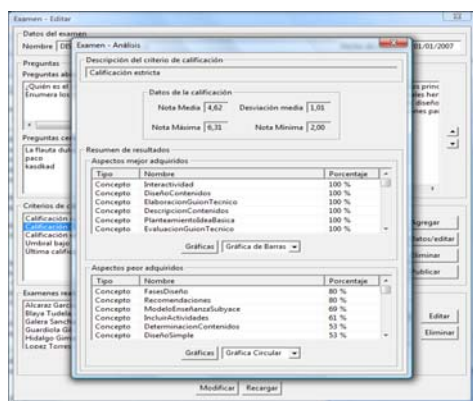


Figure 2: Providing feedback to teachers in OeLE.

Graphical feedback is also generated for the teacher. In order to get the graphical feedback, the teacher has to select the set of entities to analyze graphically, and the graph is generated. The OeLE platform generates bar and circular graphs for teachers. Bar graphs allow for viewing the selected course knowledge items ordered by decreasing percentage, whereas circular ones allow for representing and analyzing course knowledge items in relative terms.

3.3.2 Providing Feedback to Students

It has already been mentioned that the teachers can launch several marking processes for the same exam by changing the marking criteria. However, the students can only receive the mark and the feedback from one of them. This will be the one made public by the teacher. Consequently, the students receive feedback for this public assessment. This feedback is generated for each question of the exam. The feedback for open questions is different than the closed ones. The feedback for closed questions does not provide any semantic information; the platform just shows the user answer and the correct one.

An example of open question feedback is shown in Figure 3, which shows part of the feedback generated for the first question of an exam. The student can see the description of the question, the score obtained for this question (0.29), the expected answer in natural language, and the semantic analysis of his/her answer. The result of such analysis is comprised of two lists:

- Knowledge not acquired (“aspectos a mejorar”): This list contains the knowledge items that were expected to be answered in this question, but the student did not. In this example, the student did not answer the concepts “bases of design”, “phases of design” and “recommendations”, the relations “bases of design are the bases of pedagogical design” and also “bases of design are the bases of technical design”, and, finally, the attribute “main aspects of the bases of design”.
- Knowledge contained in the answer (“Items respondidos por el alumno”): The marking process obtains a set of semantic annotations from the student answer. The feedback is then generated by showing the correctness of each ontological entity extracted from the student answer. The figure only shows the concept Tools (“herramientas”) which was correctly answered by the student. Wrong items have a red cross associated.

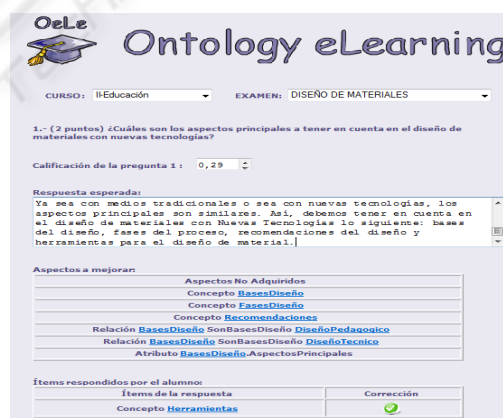


Figure 3: The feedback generated for a student.

Moreover, the ontological elements have links associated, which allow the student to see its ontological definition. For instance, in case of clicking on a concept, a web page showing its name, attributes and relations is shown. In summary, the feedback provided to each student can be seen as a personalized recommendation of topics that should be reinforced.

4 EXPERIMENTAL VALIDATION

The course “Design and Production of Educational Materials” is one of the e-learning courses in the Education Degree in the University of Murcia. This course took place in the second semester of 2008/2009, and had 25 students. All the work is realized in our virtual campus SUMA (<http://suma.um.es/>). The working processes of the students are evaluated with an e-portfolio and other different activities throughout the 9 themes of the program and also the participation of the students in several communication situations (videoconferences, forum and collaborative works). The final evaluation is carried out with two types of exams: multiple choice, and open question test. For this second phase, OeLE was used and it served for the validation of the approach.

Now, we describe the process followed in this validation experiment:

- 1) Development of the course ontology. The OWL ontology has been done using Protégé, and it has been imported into the OeLE platform. The ontology has 111 classes, 71 object properties, 51 data type properties, including also disjoint and cardinality constraints. Its consistency has been checked using Pellet, and the ontology has ALCHIN(D) DL expressivity.
- 2) Preparation of reinforcement contents: A series of HTML learning objects were designed and associated to the concepts of the course ontology.
- 3) Design of the first exam: An exam containing 5 open questions was created using OeLE, and the expected answers were annotated.
- 4) Execution of the exam: The students had to answer this test using OeLE and with a time limit. The students could review the contents of the course in the virtual environment and could search on internet to find answers during the realization of the exam. This exam was taken by 21 students.
- 5) Assessment of the exams: The exams were marked by a teacher and by OeLE.
- 6) Feedback: The students and the teacher received the marks and the feedback generated by OeLE. The students reviewed the reinforcement learning objects associated to the knowledge items suggested by OeLE.
- 7) Repetition of steps 3, 4 and 5 for the second exam. This exam was taken by 20 students.
- 8) Evaluation of the feedback: This was done by the students. Students were asked to answer a questionnaire about the effectiveness and usefulness of the learning objects and the feedback received.

The whole experiment and the results can be found at klt.inf.um.es/~oele/feedback. This includes: the ontology, the questions of the exams, the annotations of their expected answers, the reinforcement contents, samples of the annotations extracted from the students’ answers, samples of the semantic feedback generated by OeLE for the teacher and for a particular student, the marks of the students in both exams, and the questionnaire filled by the students. Next, some evaluation of the feedback results is shown.

First, we compared the results obtained by the students in both exams. If the feedback generated by the system was effective, then the students should have obtained a better mark in the second exam. The maximum possible score in an exam is 10. The average mark of the first exam was 6.18 (21 students)/6.12 (20 students) and the average mark for the second one was 6.56 (20 students). 12 students obtained a better mark, 4 obtained a worse mark and 4 obtained a similar mark. For this classification, we defined that a student obtained a similar mark is the difference was not greater than 0.25. Consequently, it seems that the feedback generated was useful for the students. However, this is a single, and small experiment so strong conclusions cannot be drawn from such results. Therefore, we asked the students to answer a questionnaire. This was designed from a pedagogical perspective and it included questions related to different issues such as usability, accessibility, quality of the learning objects and usefulness of the feedback.

Next, we discuss the results of the three questions related to the feedback. A Likert scale was used for answering to the questions. In this sense, the students had to assign a value between 1(maximum disagreement) and 4(maximum agreement). In order to summarize the results, two groups were created: agreement (3-4) and disagreement (1-2). The detailed results can be checked at the aforementioned website. These are the three questions:

- Question 1: Knowing the errors made in my exam is a waste of time.
 - Agreement: 16.7%
 - Disagreement: 83.3%
- Question 2: Showing the feedback information about the errors in my exam is positive.

- Agreement: 88.9%
- Disagreement: 5,5%
- Do not answered: 5,6%
- Question 3: I think I would have obtained the same mark in the second exam without the feedback generated by the system.
 - Agreement: 22,2%
 - Disagreement: 66,67%
 - Do not answered: 11.1%

Consequently, it can be said that the students found useful and effective the generation of the semantic feedback and that this can be useful for helping students in improving their academic performance.

5 CONCLUSIONS

Assessment is a fundamental part of the teaching-learning process. Feedback is an important component of assessment, since it is the process through which students and teachers can get precise information about the learning flaws of the students and then take effective actions. However, most current eLearning systems does not offer possibilities for providing feedback, and in most cases, they only provide a numeric score for the closed questions.

In this work, mechanisms for providing feedback based on Semantic Web technologies have been proposed, and they have been implemented in an existing software platform, with the aim of facilitating continuous learning processes and reducing the workload of teachers in these tasks. Feedback has been generated by analyzing the semantic annotations associated to the expected answer of questions, and to the answer of the students. On the teacher side, information about the weaknesses of the student is provided, so teachers can design new materials, schedule extra lessons, or extra exercises for students to overcome their learning flaws. On the other hand, students are provided with the list of knowledge items that have been correctly and wrongly answered, so that they know what they have to reinforce.

Here, semantic feedback is provided for open questions. We plan to redefine closed questions so that they will also have semantic annotations associated, that will be used to generate the feedback to the student. As further work, we will provide links to the learning objects associated to the ontological elements.

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